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**BAROMETRIC OBSERVATIONS AMONG THE HIGH VOLCANOES OF
MEXICO, WITH A CONSIDERATION OF THE CULMINATING
POINT OF THE NORTH AMERICAN CONTINENT.**

BY PROFESSOR ANGELO HEILPRIN.

Among the objects for which the Expedition, recently organized under the auspices of the Academy of Natural Sciences of Philadelphia, was dispatched to Mexico was the determination of the physical features of the giant volcanoes of the south, with special reference to a study of the vertical distribution of animal and vegetable forms. While prosecuting our observations in this direction, I took the opportunity, in company with one or more of my associates, of scaling the four loftiest summits of the land, namely: the peak of Orizaba, Popocatepetl, Ixtaccihuatl, and the Nevado de Toluca. This gave me the advantage of making personal comparisons between the life that existed in different regions of "cloud-land," at the same time that it offered me the opportunity of more closely investigating the geological features of some of the most gigantic volcanic mountains known to us. Numerous measurements of altitude were made during the ascents, and, in the higher regions, always with the same instrument. This was a registered aneroid, tested and corrected at Philadelphia—immediately before the starting, and shortly after the return of the Expedition—at the sea-level of Vera Cruz, and in the Central Meteorological Observatory of the City of Mexico, at an elevation of 7403 feet. To the officers of the latter institution I am indebted for the privilege of making comparisons with the standard mercurial column.

The results of our measurements show a striking accord in some instances with those obtained from earlier measurements, while in other cases they exhibit marked divergence. The fact that all the summits were ascended within a period of three weeks, were measured with the same instrument, and during a period of atmospheric equability and stability which is offered to an unusual degree by a tropical dry season, renders the possibility of errors of any magnitude almost nil; at any rate, such errors as may have crept in will probably not affect a general comparative result. The points of important difference are: 1, The highest summit of Mexico is not, as is commonly supposed, Popocatepetl, but the peak of Orizaba (Citlaltetpetl, the "Star Mountain"), which rises 700 feet higher (18,200

feet); 2, Ixtaccihuatl, the familiar "White Woman" of the plain of Anahuac, is but a few hundred feet (about 550) lower than Popocatepetl.

In the following summary of our results I have taken up the history of each volcano individually. The peak of Orizaba was ascended on the 6th and 7th of April, Popocatepetl on the 16th and 17th of the same month, the Nevado de Toluca on the 21st, and Ixtaccihuatl on the 26th and 27th.

THE PEAK OF ORIZABA.

The ascent of this mountain was made from the side of San Andres Chalchicomula, which lies not far from the west foot of the volcano, at an elevation of some 8,200 feet above the level of the sea. The attacking party consisted of myself, three of my scientific associates, Messrs. Roberts Le Boutillier, J. E. Ives, and Witmer Stone, and eleven guides and carriers. The two last-named gentlemen desisted from the attempt when not further than 300 feet below the summit, while the strength of the first gave out already at an altitude of about 14,000 feet. My measurements were made at a point on the rim of the crater which I estimated to be approximately 40 yards below the actual apex of the mountain; the result obtained is 18,205 feet. I append herewith the data for the determination:

Reading of the barometer at the summit, with the correction for error (.26) kindly given to me by the authorities of the Mexican Central Observatory, 15.56 inches (395.4 mm.).

Barometer at the same hour (5 p. m.) at the Mexican Observatory, 23.02 inches (584.87 mm.).

Temperature of the air on the summit, 35° F.

Temperature of the air, City of Mexico, 78°5 F.

During the ascent of the second day, and continued through the greater part of the following day, the barometer indicated a drop of .1 inch; this I determined by a re-measurement of my positions on the down slope, and through a subsequent examination of the barometric reading made at the sea-level of Vera Cruz.¹

The calculation is based upon the tables prepared by Delcros and Guyot, published in the Smithsonian Miscellaneous Collections, I.

The elements of the calculation are as follows:

¹ For the use of the daily and hourly barometric readings made at this point I am indebted to the courtesy of Captain Powell, constructing engineer of docks of the Mexican Railway.

Tables of Delcros :

Difference of barometric values . . .	3117.7 metres.
Addition for temperature . . .	173.6 “
Correction for latitude (decr. grav.) . .	7.4 “
Correction for gravity (vertical) . .	10.0 “
Correction for elevation of lower station .	2.5 “
	<hr/>
	3311.2
	=
	10,863.3 English feet.
Elevation of the Mexican Observatory	7403.0 “ “
Elevation above point of observation	120.0 “ “
	<hr/>
	18,386.3
Allowance for drop of .1 barometer	180.4
	<hr/>
	18,206

Tables of Guyot :

Difference of barometric values . . .	10,232.9 feet.
Addition for temperature . . .	563.0 “
Correction for latitude (decr. grav.) . .	22.5 “
Correction for gravity (vertical) . .	34.0 “
Correction for lower station . . .	7.5 “
Elevation of Mexican Observatory . .	7403.0 “
Elevation above point of observation .	120.0 “
	<hr/>
	18,382.9
Allowance for drop of .1 barom. . . .	178.4
	<hr/>
	18,204

This determination of the height of Orizaba is considerably above the values which have heretofore been given for the mountain. Ferrer, in 1796, by means of angle measurements taken from the Encero, determined its height to be 17,879 feet.¹ Humboldt, a few years later, measured the mountain from a plain near the town of Jalapa, and obtained only 17,375 feet,² but he observes with char-

¹ Humboldt, *Cosmos*, V, p. 252, Bohn's Edition. I have not been able to find the original account of this measurement, but there is a brief note, entitled "Height of some Mountains in New Spain," and published by Ferrer in the 6th volume of the *Transactions of the American Philosophical Society* (p. 164), in which the height here stated (or its equivalent, 2795 toises) is given.

² *Op. cit.*, V, p. 252.

acteristic caution that his "angles of elevation were very small, and the base-line difficult to level." He in fact, rejects his measurement in favor of the one by Ferrer, remarking that he was "still uncertain which of the two volcanoes, Popocatepetl or the peak of Orizaba, is the highest." No carefully conducted measurement appears to have been made between this time and 1877, when a Mexican scientific commission, composed of MM. Plowes, Rodriguez, and Vigil, made the ascent of the volcano from the side of San Andres Chalchicomula. A barometer registering to 14,000 feet was used for approximate determinations up to that height, but the actual measurement of the summit was made trigonometrically from the plain of Chalchicomula. The results obtained ¹ give an elevation above the town of Chalchicomula of 9211 feet (2807.84 metres), or, computed by the same observers for the sea-level of Vera Cruz, 17,664 feet. It must be observed here, however, that the elevation of Chalchicomula, which served as the base for the trigonometrical measurement, and which is given by these authors as 2576.3 metres or 8452.6 feet, is placed approximately 250 feet too high. The leveling of the Mexican Railway places the station of San Andres at 7974 feet. I measured barometrically the rise of the tramway which connects San Andres with Chalchicomula (or more properly, San Andres Chalchicomula), a few miles distant, and found only 230 feet. The town can therefore be elevated only about 8200 feet. Deducting the excess from the figures of the Mexican commission we have 17,415 feet, a result strikingly close to that obtained by Humboldt, but which that investigator felt obliged to question and to reject.

I am not aware of the reasons which have prevented the acceptance of the results of the Commission by Mexican geographers, unless it be that an implicit confidence in the researches of Humboldt has given marked preference to the earlier measurement. Thus Garcia Cubas, in the 1885 edition of his magnificent "*Cuadro geográfico, estadístico, descriptivo, é historico de los Estados Unidos Mexicanos*," still retains the figures of the illustrious German savant. This preference for Humboldt's measurement is in the present instance the more suprising in view of the doubt which Humboldt himself expresses regarding its accuracy. German geographers have, on the other hand, very generally accepted Ferrer's figures (17,879 feet), or

¹ *Annales del Ministerio de Fomento*, III, 1877, pp. 99 and 113.

the late determination by Dr. Kaska, by means of a mercurial barometer, which gave 5500 metres (18,045 feet.)¹

POPOCATEPETL.

The ascent of this mountain was made by Mr. Baker and myself, with the assistance of five guides and carriers, from the side of Ameca, just nine days after our descent from the peak of Orizaba. As compared with the ascent of the latter volcano, that of Popocatepetl is easy, although even here a good constitution and a goodly amount of endurance are required. But neither the ascent of Popocatepetl nor that of Orizaba is dangerous in the sense that Alpine climbing really is, although trouble might arise from the difficult respiration of the rarefied atmosphere. The Orizaba Commission, indeed, lost two of its assisting members, (guides or porters) as a direct consequence of this rarefied atmosphere.

We reached the northern rim of the crater, the *ultima thule* of most ascensionists, at 11 o'clock in the morning of the second day, and the culminating point, which lies toward the southwest, overlooking the State of Morelos from a still greater elevation of 700 feet, at 1.40 p. m. Barometric observations made at this point indicate an absolute elevation, as computed from the readings of Mexico City, of 17,513 feet, and from Vera Cruz of 17,533 feet, or an average of 17,523 feet. The data for the measurement are:

Barometer on the summit, with determined

correction, 16.04 inches	(407.5 mm.)
Barometer in City of Mexico	585.55 mm.
Barometer at Vera Cruz	29.91 inches.
Temperature of the air on summit . .	45° F.
Temperature City of Mexico	23.5° C. (74°3 F.)
Temperature City of Vera Cruz approx.	83° F.

The elements of the calculation are as follows:

Tables of Delcros (calculated from the readings at the City of Mexico):

Difference of barometric values	2886.3 metres.
Addition for temperature	177.3 “

¹ Meyer's *Konversations-Lexikon*, article Orizaba.—Grisebach, in his *Veg-
etation der Erde*, (2d Ed., II, p. 563, 1884), quotes Müller as having obtained a
trigonometrical measurement of the volcano of 17,000 French feet (18,112 English
feet.) Unfortunately I have been unable to obtain access to Müller's *Reisen*, and,
therefore, do not know the details of this measurement.

Correction for latitude (decr. grav.)	.	.	.	6.9 metres.
Correction for gravity (vertical)	.	.	.	9.0 "
Correction for elevation of lower station	.	.	.	2.2 "

 3081.7

	=	10,110.4 English feet.
Elevation of Mexican Observatory		7403.0 " "

 17,513 feet.

Tables of Guyot :

Difference of barometric values	.	.	.	9472.9 feet.
Addition for temperature	.	.	.	582.0 "
Correction for latitude	.	.	.	20.0 "
Correction for gravity	.	.	.	29.9 "
Correction for lower station	.	.	.	6.0 "

 10110.8

Elevation of Mexican Observatory	.	.	7403.0
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 17,513.8 feet.

Computed from the readings at Vera Cruz :

Tables of Guyot :

Difference of barometric values	.	.	.	16,279.6 feet.
Addition for temperature	.	.	.	1157.6 "
Correction for latitude	.	.	.	35.0 "
Correction for gravity	.	.	.	58.4 "
Correction for lower station	.	.	.	3.0 "

 17,533.6 feet.

It is not necessary in this place to recite all the previous measurements of Popocatepetl that have been made, which in a general way agree in giving the mountain an elevation of from 17,400 to 18,000 feet. The brothers Glennie reached the highest point of the crater-wall on the 20th of April, 1827, and by barometrical observations deduced its height to be 17,884 feet.¹ The opposite to the extreme

¹ Humboldt (Cosmos, V, p. 458 Bohn's Edition) states that this measurement had been corrected by Burkart into 18,017 feet. I find no reference to this correction in Burkart's original communication (translation of Glennie's narrative) published in Schweigger's Jahrbuch der Chemie und Physik, XX, pp. 385 et seq., 1827. Glennie, however, gives the pressure of the barometer as 15.63 inches, which, if taken under conditions similar to those which marked our own measurements, would indicate a value of upward of 18,000 feet. But no statement is made as to the testing of the barometer for accuracy.

high measurement given by Glennie is that of Truqui and Craveri, who ascended the mountain in September, 1855, and found, at a point estimated to be about 50 metres below the virtual summit, a barometric value (as computed by them) of 5230 metres (=17,159 feet.)¹ Their barometric reading (409 mm.), made a short distance beneath the summit, would, if reduced to the summit, coincide almost exactly with our own; and I fail to see, in view of the common datum accepted for Vera Cruz, how our culculated results should differ to the extent that they do (380 feet). The difference should not exceed some 50-75 feet, but since Truqui and Craveri give no formula of their computation, it is impossible to determine whence the divergence arises.

The most extensive series of measurements made to determine the height of Popocatepetl are those of August Sonntag (1857), published in the Smithsonian Contributions to Knowledge (XI), and incorporated in an article entitled "Observations on Terrestrial Magnetism in Mexico." The average of three series of measurements (barometric and trigonometric, and varying from one another in very narrow limits) gives 17,785 feet for the height of the mountain, or almost exactly 100 feet less than that given by Glennie. We are informed (p. 78 of paper) that the basal height upon which all other elevations are calculated is that of the plaza of the City of Mexico, which is assumed to be 7472.8 feet. The more recent leveling of the Mexican Railway shows, however, that this figure is in excess by 125 feet (Mexico 7347 feet), an amount which has consequently to be deducted from Sonntag's estimate. This would leave 17,660 feet, or about 140 feet in excess of my own measurement.

Most geographers still follow Humboldt's determination, made in 1804, which allows for the volcano little more than 17,700 feet. This measurement was made from the Llano de Tetimba, lying on the east or Puebla side of the mountain at an elevation, computed barometrically, of 2405 metres. The trigonometrical determination of the summit from this point gave 2993.7 metres, or an absolute

¹ Petermann's *Mittheilungen*, 1856, p. 361.

² Usually given as 17,720, 17,726, or 17,728 feet. The exact figure should be 17,713 feet (5399 metres, 2770 toises), as given in a letter addressed by Humboldt to Dr. Petermann, under date of December, 1856, and published in Petermann's *Mittheilungen* for the same year (p. 479). But Humboldt himself, or rather his translator, erroneously gives 17,729 and 17,728 feet, on pages 251 and 458 of the fifth volume of his *Cosmos* (Bohn's Edition).

elevation of the mountain of 5399¹ metres (17,713 feet). But here, as in the case of Sonntag's measurement, we have to allow for the difference in the height of the Mexican plateau which has been established by the recent railroad levellings. There are as yet no data as to the "railroad" height of the plain of Tetimba, the elevation of which was determined barometrically by Humboldt; but we have reason to believe that the measurement by the illustrious German traveler was made with the same instrument which also determined for him the elevation of the City of Mexico. This is given as 7470.6 feet (2277 metres²), which is in excess of the railroad levelling by 123 feet. Deducting this amount from 17,713 feet we obtain 17,590 feet as the expression of Humboldt's measurement. This is in marked correspondence with my own determination.³

IXTACCIHUATL.

The ascent of this mountain was made by Mr. Baker and myself from the side of Ameca on the 26th and 27th of April, just ten days after our ascent of Popocatepetl. This mountain, although less high than either Orizaba or Popocatepetl, is really the giant of the Mexican volcanoes, and it bears evidence of having been at one time much more elevated than it is to-day. The earliest recorded ascent, so far as I have been able to determine, was made in the November previous to our visit by a resident of Miraflores (Selis? by name), who, I believe, succeeded in reaching the virtual summit. We were somewhat less fortunate, as two impassable crevasses, cutting directly across the crest of the mountain, prevented further progress at a height of a little over 16,730 feet. This position I estimated to be some 75 yards below the highest point.

¹ This figure allows for a correction by Oltmanns; Humboldt himself obtained only 5387 metres (17,674 feet), but he admitted the correction made by his astronomical associate.

² Petermann's *Mittheilungen*, 1856, p. 481.

³ If we take Humboldt's own measurement, without the correction suggested by Oltmanns, 17,674 feet, and deduct from this amount the excess of 123 feet, the result obtained (17,551 feet) will still more nearly approximate my own.—Messrs. Dollfus, DeMontserrat and Pavie, of the French Scientific Commission, ascended the mountain on the 23rd of April, 1865, but they were unable to attain the highest point, the Pico Mayor. They give 5,263 metres (barometric measurement) as the elevation of the highest point reached by them, the southeastern rim of the crater (*La Naturaleza*, 1870, p. 184; *Archives de la Commission Scientifique de Mexique*, II, p. 127, as quoted in Petermann's *Mittheilungen*, 1868, p. 98.)

Of the three giant volcanoes of Mexico this is by far the most difficult of ascent, and the only one which partakes of the full dangers of Alpine climbing. A vast covering of snow and ice, some 50–100 feet in depth, forming a true *firn* or *névé* shrouds the summit in one continuous mantle, from which several glacial streams descend the slopes to a depth of some 14,500 feet. It was across one of these, which I now propose to name the Porfirio Diaz Glacier, that our course was directed, a course that zig-zagged in steep windings around the deep *barrancas* (crevasses) which everywhere cut into the ice. We reached our ultimate position shortly before 11 o'clock of the morning of the second day. The data for our determination of height are the following:

Barometer on summit, with determined correction, 16.44 inches	(417.8 mm.)
Barometer in City of Mexico	587.4 mm.
Barometer in Vera Cruz	30 inches.
Temperature of the air on summit	32° F.
Temperature City of Mexico	21° C.
Temperature City of Vera Cruz (approx.)	85° F.

The elements of the calculation are as follows:

Tables of Delcros (computed from Mexico):

Difference of barometric values	2713.1 metres.
Addition for temperature	113.9 “
Correction for latitude (decr. grav.)	6.5 “
Correction for gravity (vertical)	8.6 “
Correction for elevation of lower station	2.3 “
	<hr/>
	2844.4 metres.
	<hr/>
	= 9332.4 English feet.
Elevation from summit (estim.) 75 yards	225.0
Elevation of Mexican Observatory	7403.0
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	16,960

Tables of Guyot (computed from Vera Cruz):

Difference of barometric values	15714.5 feet.
Addition for temperature	925.4 “
Correction for latitude	33.0 “
Correction for gravity	55.0 “
Correction for lower station	3.0 “
Distance of point measured from summit (estim. 75 yards.)	225.0 “
	<hr/>
	16,956 feet.

This determination is in excess by 1250 feet of the results obtained by Humboldt (4786 metres, ¹ or 15,702 feet), whose measurement is still followed by some geographers,² and nearly 900 feet above the estimated height given by Mexican geographers. Thus, Garcia Cubas, in the work already mentioned, gives 4900 metres (=16,076 feet), and the same figure also appears in a small work entitled "Geografia de Mexico," prepared by Alberto Correa, and adopted for use in the public schools of the Mexican Republic (1889). I am wholly at a loss to understand how, in view of the close proximity of Ixtaccihuatl to Popocatepetl, either Humboldt or the Mexican geographers could have felt satisfied with the low values obtained for this mountain. Both volcanoes appear to be so nearly of the same height that the eye almost fails to determine which is the loftier of the two, and, indeed, there are to-day many residents of the capital city who affirm that Ixtaccihuatl is the more elevated.³ Sonntag, who made an ineffectual attempt to gain the summit, long since (1857) made careful measurements of the height of the mountain, and his results, obtained by triangulation, and published in the Smithsonian Contributions to Knowledge, XI, are strikingly confirmatory of my own. His value for the central elevation, the highest of the three summits or peaks, is 17,076.9 feet; deducting from this amount the 125.8 feet difference in the elevation of the City of Mexico, to which reference has already been made in our account of Popocatepetl, we obtain as a net result 16,951 feet, or a variation of less than 10 feet from my own measurement. It is rarely that so close a correspondence is established between the barometric and trigonometric measurements of a mountain of the altitude of Ixtaccihuatl.

NEVADO DE TOLUCA.

Mr. Baker and myself ascended this mountain from the side of Toluca, or rather from that of San Juan de las Huertas, on the 21st of April, three days after our descent from Popocatepetl, and five days before our journey to Ixtaccihuatl. Being considerably lower

¹ *Essai Politique Nouv. Espagne*, XCI; 14,736 French feet, in *Kleinere Schriften*, p. 463.

² See article "Mexico" in *Encyclop. Britann.*, 9th ed., p. 215.

³ It is the belief of many tourists, and of natives of Mexico as well, that Humboldt ascended one or more of the three giant peaks of the Republic; this belief is ill-founded, since the highest point reached by him was the apex of the Nevado de Toluca, about 15,000 feet.

than either of the other volcanoes, its ascent is correspondingly easier; indeed, a horseman can ride with his animal to within about 900 feet of the summit. Beyond this point the ascent, which is conducted over a precipitous slope composed in great part of detached boulders, is very fatiguing, but not strictly dangerous. The crest of the disrupted crater-wall is exceedingly jagged and abrupt, and in places narrow enough to be straddled. We found very little snow or ice on the summit, and I believe none was visible except in rock shelters. The mountain is thus scarcely worthy of the designation of *nevado*. Our measurement for the height of the peak gives 14,953(5) feet. The data are as follows:

Barometer (with correction) on summit 17.53 inches (445.3 mm.)

Barometer City of Mexico (approx.) 23.01 inches (584.5 mm.)

Temperature of atmosphere on summit . . . 44° F.

Temperature City of Mexico 21.°6 C. . . 70.°9 F.

The elements of the calculation are:

Tables of Delcros.

Difference of barometric values . . .	2166.0 metres.
Addition for temperature . . .	122.5 "
Correction for latitude (decr. grav.) . . .	5.3 "
Correction for gravity (vert.) . . .	6.6 "
Correction for elevation of lower station . . .	1.7 "

2302.1 metres.

= 7552 English feet.

Elevation of Mexican Observatory .	7403	"	"
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14,955

Tables of Guyot:

Difference of barometric values . . .	7106.8 feet.
Addition for temperature . . .	402.0 "
Correction for latitude . . .	15.0 "
Correction for gravity . . .	21.5 "
Correction for lower station . . .	4.5 "
Elevation of Mexican Observatory . . .	7403.0 "

14,953 feet.

I am not sure but that there is a point on the crater-rim which rises some 15–20 feet above that where we made our measurement.

I was not, however, able to determine this, as the lateness of the hour prevented our reaching the position in question. Humboldt's barometric measurement of the Pico del Fraile gave 4621 metres¹ or 15,161 feet; deducting the excess of 123 feet from his determination of the elevation of the City of Mexico we obtain 15,038 feet, or about 80 feet more than my own calculations show. Garcia Cubas reduces this difference by some 18 feet, giving as the height of the mountain 4578 metres (15,020 feet).²

Tabulating the results of our measurement of the four highest volcanoes we find for:

Peak of Orizaba	18,205 feet.
Popocatepetl	17,523 feet.
Ixtaccihuatl	16,960 feet.
Nevado de Toluca	14,954 feet.

Some slight alteration of these values, due to the effects of a varying temperature upon the mechanism of the aneroid, ought perhaps to be made; but the correction is an unknown quantity, and I have found that a change of from 20 to 30 degrees F. failed to produce any appreciable difference in the reading.

THE CULMINATING POINT OF THE NORTH AMERICAN CONTINENT.

The restoration of the Peak of Orizaba to the first place among Mexican mountains, and its increased altitude, open up the interesting question as to what constitutes the culminating point of the North American continent. The only other mountain that need be considered in this connection is St. Elias, situated approximately on the 141st parallel of W. longitude, and whose summit is claimed for both the possessions of Great Britain and the United States (Alaska). The measurements of this mountain depart so widely from one another, however, that we are not yet in a position to affirm, even within limits of 1000 feet or considerably more, how nearly it approaches in height the Mexican volcanoes. We are probably justified in dismissing without further examination the

¹ *Essai Politique Nouv. Espagne*, XCI; 15,168 feet, in *Cosmos*, V, p. 281, Bohn's Edition.

² I was informed in the town of San Juan that a number of students from the engineer's college of Toluca determined trigonometrically the height of the Nevado to be 4444 metres or 14,580 feet. I feel certain that this estimate is several hundred feet too low.

measurement made by La Pérouse in 1786, which gave for the peak less than 13,000 feet; and seemingly not much more reliable is the datum (14,970 feet) which appears in Captain Denham's chart from 1853 to 1856, and is copied into the British Admiralty chart of 1872 (Humboldt's *Cosmos*, V, p. 419, Otté's Edition; Dall, Rept. U. S. Coast and Geodetic Survey for 1875, p. 159). This latter figure (4562 metres) is adopted by Petermann in his general map of North America prepared for Stieler's *Hand-Atlas* (1878-81). Malespina in 1791 determined the height, by means of angles taken from near the position of Port Mulgrave, to be 5441 metres or 17,851 feet, and the equivalent of this figure has been copied into the Russian Hydrographic charts (1847). Tebenkoff reduces this amount by somewhat over 900 feet.

No carefully conducted measurements of the mountain appear to have been made between the date of the publication of Tebenkoff's chart (1849) and 1874, when Mr. Dall, under the direction of the U. S. Coast Survey, surveyed a considerable portion of the Alaskan region.¹ This investigator found four different values for the height of the mountain as measured from four points respectively 69, 127, 132, and 167 miles distant: these are 19,464, 18,350, 19,956, and 18,033 feet. Mr. Dall dismisses all of these as having little value, except the measurement of 19,464 feet, made from Port Mulgrave. It is difficult to reconcile the vast range of these measurements, whose extremes vary to an extent of upwards of 1900 feet, or to one-tenth of the height of the entire mountain, except on the assumption that the angles of measurement were too small to permit of exactitude in the result. And, indeed, Mr. Dall himself rejects

¹ Mr. Dall, in his report above referred to (p. 159), quotes from Leopold von Buch an additional measurement of the mountain, namely 16,758 feet. Grewingk (*Verhandl. Russ.-Kaiser. Mineralog. Gesellsch.*, 1848-9 [1850], p. 99), gives the same figure, referring likewise to Buch (*Canar. Inseln*, p. 390); and a further reference appears in Davidson's "*Coast Pilot of Alaska*," 1869, p. 142, note (16, 754 feet, according to Grewingk). But this figure is manifestly Malespina's measurement given in *French* feet, which resolved=17,860 feet; and Grewingk himself quotes Malespina's measurement (5441 metres) on p. 404 of his report. Humboldt (*op. cit.* V, p. 252) credits the measurement of 17,855 feet to Quadra and Galeano, but as these observers were associated with Malespina, it is more than probable that the data here given are those which have been generally attributed to Malespina. Humboldt intimates that the measurement is perhaps one-fifteenth too great, but whether this assertion rests on certain facts contained in Malespina's manuscripts, which the great German traveller found among the Archives of Mexico (p. 419), or not, is not stated.

all his measurements except those made from Port Mulgrave, giving them "no weight in the result, as they were all taken at great distances from the peak, and subject to various disturbing influences and uncertainty in most of the positions (p. 164)." And yet it is upon the accurate determination of the position "At Sea," 127 miles distant, that "the position of Mount Saint Elias depends" (p. 165); and necessarily upon the determination of this position must also depend the accuracy of the measurement of height. Malespina's measurement was made from a point apparently very close to that occupied by the Coast Survey Officers, and his results, as has already been seen, vary negatively by 1600 feet; but he estimated the distance separating him from the mountain at 55.1 nautical miles. Mr. Dall remarks, in relation to the discrepancy existing between the two measurements, that the doubt lies wholly with the distance. But this does not explain the great range in Mr. Dall's own results. And we are perhaps led to be the more suspicious regarding the value of these when we take into account the discrepancies which appear in the determination of the altitude of Mount Fairweather. Three series of sextant observations were made of this mountain from the region about Lituya Bay and Cape Spencer, with the result of obtaining an average value of 15,447 feet. Vertical circle measurements of the same mountain made from Port Mulgrave indicate 15,270 feet, while the average of all measurements is 15,423 feet. Mr. Dall calls attention to the close correspondence of these results, and comments more particularly upon the "unanimity in the Lituya Bay observations."¹ A reference to the exact results obtained, without recourse to the delusive system of extracting averages, shows, however, that in place of unanimity we have the reverse. Thus, the sextant observations taken from "Off Cape Spencer" indicate 16,009 feet, those from "Off Lituya Bay" 15,247 feet, and those from "Off Lituya" 15,085 feet (*op. cit.* p. 174) a difference in extremes of upward of 900 feet. This divergence in the measurement of a mountain three miles (\pm) in height from positions 20-50 miles distant makes very doubtful the results obtained in the case of St. Elias, where the distances were still very much greater, and the angles of observation correspondingly smaller.

In view of the broad divergence existing in these later measurements, and the fact that all earlier determinations give less than 18,000 feet for the height of Mount St. Elias, geographers will prob-

¹ Including here the measurements made off Cape Spencer.

ably consider the question of absolute height as still an open one. That the mountain closely approximates the giants of the Mexican plateau is almost certain, but it seems equally probable that its true position is after, and not before, the Peak of Orizaba.